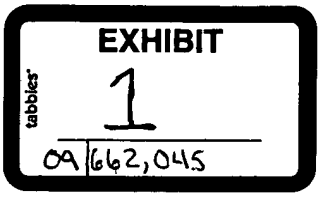

VectorVision

BrainLAB

Med. Computersysteme GmbH

User Manual

VectorVision
Rev. 3.5

BrainLAB MANUAL

VectorVision

CURRENT DOCUMENTS

This manual has been compiled especially for you! It contains all necessary chapters to fully describe your system as ordered. The list below indicates the current revisions of all available chapters in conjunction with the current software revision. Note, not all chapters are included in this manual necessarily.

Chapter	Revision
Tutorial	3.5
PatXfer	3.5
Basic Software Functions	3.5
Stereotactic Planning	3.5
Headring	3.5
Cranial Navigation	3.5
Spinal Navigation	3.5
Microscopy	3.5

VectorVision

☎ If you cannot find information in this user manual, you can call the next available BrainLAB customer support.

North & South America: +1-800-597 59 11

Europe & rest of the world: +49-89-99 15 68 44

Internet If you have acces to the Internet, you can reach BrainLAB support at

E-mail: support.neuro@brainlab.com

URL: http://www.brainlab.com

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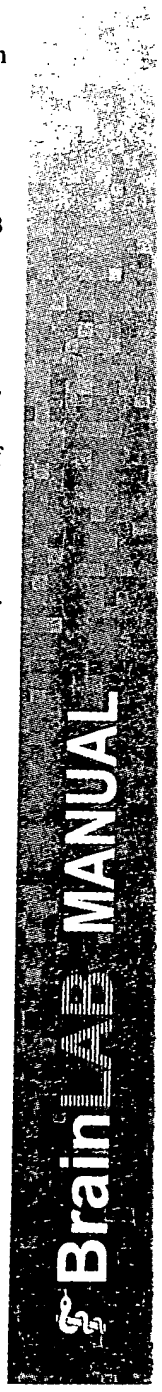
Microsoft and Windows are registered trademarks of Microsoft Corporation.

Mayfield is a registered trademark of Ohio Medical, Inc.



VectorVision

HOW TO USE THIS MANAUAL

This book is written for all members of the clinical team who use or handle the system or parts of it.

Visual Cues

WARNING

warnings are used to alert the user to possible injury, death or other serious adverse reactions associated with the use or misuse of the device.

CAUTION

Cautions are used to alert the user to the possibility of a problem with the device associated with its use or misuse. Such problems include device malfunctions, device failure, damage to the device or damage to the property.

Bold

Terms written in **bold** style refer to terms as used in the software.

SYMBOLS

The following symbols may be found on the the VectorVision rack:

Type B equipment

Attention! Please consult accompanying documents

Potential equalization point

Cranial Navigation

TABLE OF CONTENTS

INTRODUCTION

BrainLAB VectorVision is an intraoperative image guided localization system. It links a freehand probe, tracked by a passive marker sensor system to virtual computer image space on a patient's preoperative CT or MRI images. The system consists of two infrared cameras that emit infrared flashes. These flashes are reflected by passive marker spheres mounted on the Mayfield headrest and selected surgical instruments. The infrared reflection images of the markers are digitized by the two cameras, each of which "sees" the markers on the Mayfield headrest and instruments from a different angle. The software uses both images to calculate the three dimensional position of each marker sphere and therefore the 3-D position of the entire instrument relative to the headrest which is rigidly fixed to the patient's head.

When designing the software, one of the major challenges was to determine the identity of the various marker images seen by each of the cameras. Which markers seen by one camera correspond to which markers seen by the other camera? In addition, it was necessary to deduce which markers correspond to which tool. This is a specific problem that only occurs in passive marker systems, making the software design magnitudes more complicated than for mechanical or active infrared systems. BrainLAB solved these by tracking the sequential instrument positions as they move. Using known distances, and other geometric information available to the software, it is able to deduce the identity of the markers.

The described principle makes it necessary that the cameras have an unobstructed view of the tool markers at all times that the navigation is desired during the surgery. This requires careful planning of the procedure and preparation of site. It is important, therefore, that the following information be read carefully before starting a case. It is also recommended to become familiar with this new technology by first using a phantom in a mock surgical setting. After a complete procedure has been simulated successfully, the system next should be used with selected operative cases where surgical guidance may be desirable but not essential. Once the user has gained sufficient experience with the system, it then may be implemented in situations where the navigation is considered crucial.

SETUP INSTRUCTIONS

The logistics of working with the system depend on many local parameters that are specific to each institution. We suggest that the beginning user go through this chapter carefully and repeatedly until all issues related to new set-up have been resolved for your site. This will smooth the clinical implementation of the system, keeping the impact on usual practices to a minimum. The advantages of intraoperative neuronavigation should not be offset by the added time and complexity required for setting up.

The operating room

Since the system is to be placed in the operating room, its position needs to be carefully planned before the procedure starts. There is no universal solution, as the architecture in the set-up of each operating room and each procedure may differ. The following aspects need to be taken into account:

- The cameras should be within a distance of one to two meters from the surgical sight.
- An unobstructed view of the two upper ends of the Mayfield headrest as well as the surgical probe should be provided to both cameras.

Camera angle

The camera angle should be flat enough, so that also a microscope that might be used later during the procedure will also not obstruct the view.

- The trolley, to which the cameras might be attached, should be positioned to provide the surgeon a convenient view of the monitor screen.
- The computer should be accessible for an operator to change any of the display settings.
- The computer and none of the other parts of the system should be too close to the sterile components.

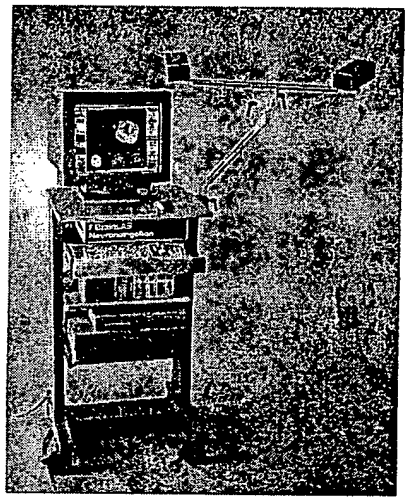


Figure 1: Trolley with camera arm

Trolley

According to our experience, the trolley provided by BrainLAB as an option in conjunction with the arm for attaching the cameras to the trolley provides the necessary flexibility to accommodate those requirements. There seem to be two preferred positions within the operating room for the VectorVision system:

- ***At the patient's right hand side behind the OR nurse.***

Assuming the microscope is at the supine patient's left-hand side with the anesthesiologist behind the microscope, there is no remaining space at patient's left side. Assuming also that the OR nurse is at the patient's right shoulder right next to the surgeon, there is space behind her. This is also the place where the rack of endoscopic equipment is often located for endoscopic procedures. The arm holding the VectorVision cameras is then positioned over the patient's abdomen, looking towards the patient's head. This position typically minimizes the frequency of obstructions during the procedure. Since the arm provides two vertical positions, the cameras also can be mounted in a way that the viewing angle is flat enough to look under the operating

microscope, if it is brought in later in the case. This position also provides ideal visual access for the surgeon to the monitor. If the OR nurse is concerned about the proximity to the sterile equipment, a drape can be positioned between the computer rack and the instrument tray.

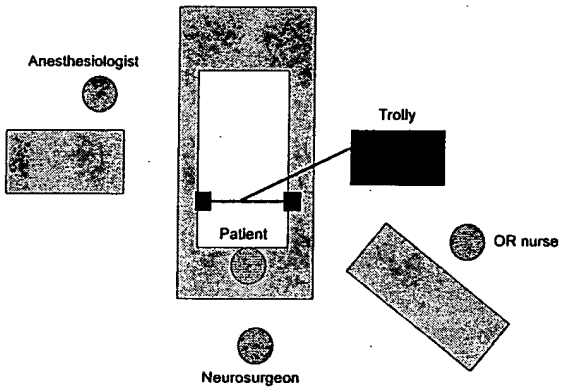


Figure 2: Position of the trolley

- ***Behind the surgeon's left or right shoulder.***

This position provides the largest flexibility during the procedure to change the position of the camera in order to remove any obstruction that might occur. This position allows easy to access for an operator to change the trolley position or some of the computer display parameters during the procedure, but the position may be inconvenient for the surgeon to view the monitor. Even when cameras are looking at a 45-degree angle over the surgeons' shoulders, the rack with the computer screen may be at the surgeon's left or right side. This requires the surgeon only to turn the rack to the right or the left, depending where the rack is located. Another advantage of this position is that all the issues related to space constrains are far less critical.

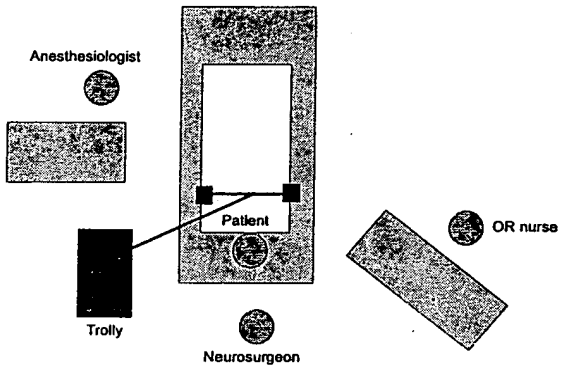


Figure 3: Position of the trolley

Camera mounting alternatives

The two alternatives described above only reflect the most commonly used solutions. However, the system is flexible enough to accommodate a much wider range of options. The cameras could be separated from the computer rack and mounted to the side rails of the operating table (contact BrainLAB for the necessary adapters). This will allow the user to independently position the computer rack wherever it is convenient for the procedure. The disadvantage is the handling of a larger number of components. Another option is to mount the cameras to the ceiling of the operating room by an arm similar to the holder of the lamps in the OR. A sterile handle will allow the cameras to be repositioned by the surgeon as necessary during the procedure. But, the camera cables still need to be connected to the computer and there will be additional cables hanging from the ceiling. We recommend handling such special attachment options through local engineers, as this enables the best and fastest adaptation to local requirements. From the software standpoint there is no restriction with regard to the mounting mechanism used for the cameras. Remember that an advantage of the VectorVision technology is that the camera array can be moved about freely during the procedure as long as it is moved as a unit without movement of one camera with respect of the other. The constraint is that the distance of the cameras to the objects being tracked should be between one and

two meters.

Pre-processing of image data

The BrainLAB software provides a wide range of functions for object segmentation and visualization of various structures. Depending on the specifics of a procedure and the anatomical structures, some preprocessing time is needed. This pre-processing can typically be done by one person while the patient is prepared for the procedure and usually requires no more than 10 to 15 minutes. In some cases, a preferred alternative is to place a second system in the neurosurgeon's office or separate computer workroom to independently preprocess the data. This arrangement may offer special advantages to those centers, which might otherwise require bulky input devices, such as half inch tape drives, to be in the operating room for image data transfer. It should be further emphasized, that the additional computer station might improve the convenience of a number of additional features that may be useful for a neurosurgeon, such as planning biopsy and other stereotactic work.

Sterilization

All devices should be gas sterilized. In an emergency, pointer tool and instrument adapters may be autoclaved at 134°Celsius, but this is **not** recommended as standard procedure.

CAUTION

The reflective marker spheres of the VectorVision system may only be sterilized by gas or plasma! Any other sterilization technique, particularly heat, will destroy the markers. BrainLAB will not be liable to any damage to the markers due to improper sterilization.

WARNING

The pointer tool should be handled with extreme care (especially during sterilization procedures) and any observation on a bend pointer tool tip should be reported to BrainLAB support. Working with a bend Pointer will lead to extreme inaccuracy during referencing of the patient and causes a hazard for the patient during navigation.

Marker Spheres

The marker spheres are attached by a threaded screw post to the pointers and instrument adapters. They can be easily unscrewed and sterilized separately. For a heavy case load it might be recommended to have additional marker spheres available as a backup or in case multiple cases are to be done at the same day. In an emergency situation, one can remove the marker spheres, autoclave the instruments, and attach new sterile markers.

BrainLAB is currently working on reducing the manufacturing cost of those markers, in order to provide disposable markers, which will significantly simplify the logistics of such a case.

Draping

Another step that requires careful training and preparation is draping. There are two approaches:

- ***Standard referencing procedure:***

Standard referencing

1. Fully drape the patient as usual.
2. Mount the Mayfield Reference Clamp.

procedure

3. Reference the patient with the sterile pointer through the drape.

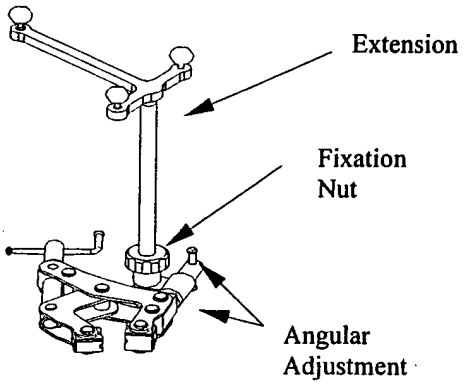


Figure 4: Mayfield reference clamp

New referencing procedure

1. Drape one side of the Mayfield.
2. Mount the sterilized VectorVision Mayfield Reference Clamp to the Mayfield over the drape (Figure 5).

⚠ WARNING

Make sure that all screws are tightly fixed before you start referencing the patient.

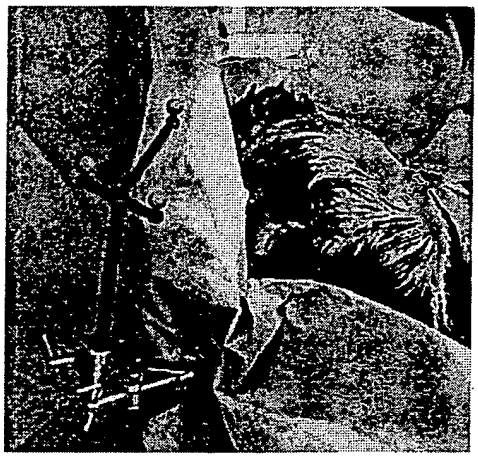


Figure 5: The mounted Mayfield Reference Clamp

3. Adjust the Mayfield Reference Clamp in a way that the Extension (with the three reflective balls) is near the planned craniotomy, in the visual line of both cameras; you can utilize the Angular Adjustment Screws at the lower part of the Mayfield Reference Clamp for positioning.
4. Start VectorVision.
5. Reference the patient as displayed in Figure 6) with a sterile pointer (at least three CT markers are necessary, we recommend five CT markers); if you have only one pointer, it would be advisable to purchase a second pointer for this procedure

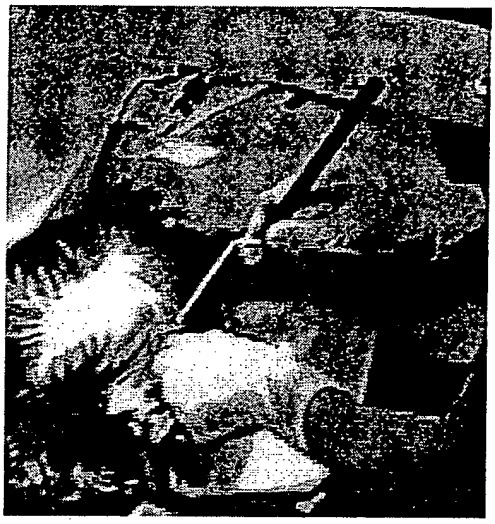


Figure 6: Referencing the patient

CAUTION

Make sure that the Mayfield Reference Clamp is not being touched with an unsterile part of the pointer or any other unsterile objects.

Unscrew the Extension (with the three reflective balls) (

6. Figure 7).

⚠ WARNING

Do not open any of the Angular Adjustment Screws after you have completed patient referencing. Only the screw marked "Fixation Nut" can be opened to remove the extension (top of the Mayfield Reference Clamp).

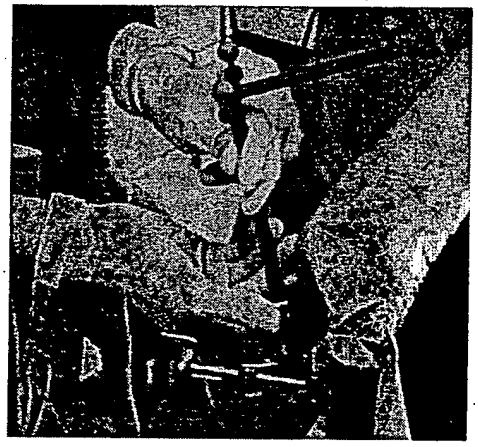


Figure 7: How to unscrew the Extension

7. Drape the patient as usual, but provide access for remounting of the Extension.

ɜ you are ready to use VectorVision, just remount the nsion and tighten the Fixation Nut (Figure 8). The field extension will be at exactly the same position as ıg referencing (tested accuracy 0.1mm)

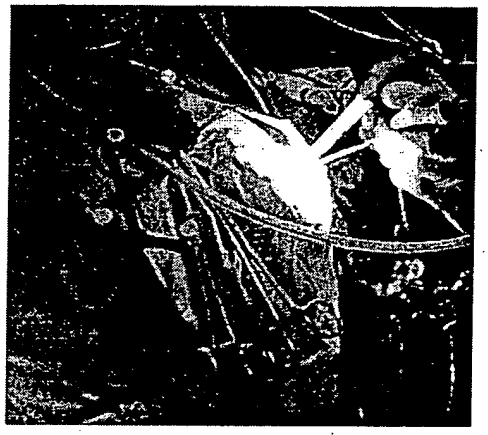


Figure 8: The re-attached Mayfield Reference Clamp

8. You do not need to re-reference the patient.

⚠ WARNING

After each remounting of the Extension, please check the accuracy of the tracking system for safety reasons.

Remount Option ıe Extension is in your way during preparation of the iotomy, simply unscrew it using the Fixation Nut. You can ɔunt the Extension at any time when you want to use :orVision.

Advantages ıuse there is no draping of the patient during referencing this new procedure, there is less movement of the CT ɛers. The system has been proven to be two times more rate for this reason.

WARNING

Make sure that the Mayfield reference clamp is rigidly fixed on the Mayfield headrest, any movement of the Mayfield independent from a movement of the patients head causes inaccuracy and a hazard for the patient.

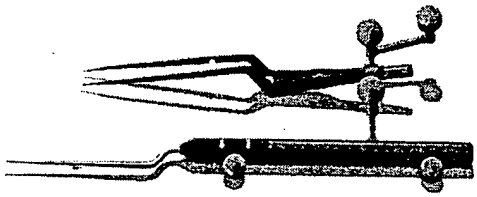


Figure 9: Pointer tool and bipolar forceps with attached marker array

CAMERA CALIBRATION

CAUTION

Every time the distance of the cameras has been changed or are supposed to be changed due to bouncing against doors or walls during transportation, the calibration procedure needs to be repeated to ensure the system's precision and functionality.

Camera Calibration

Camera Calibration from the **VectorVision** pull down menu.

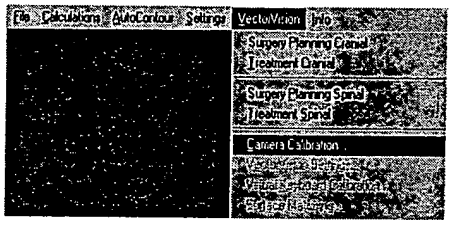


Figure 10: Camera Calibration

Camera Calibration should occur even before the patient is involved. This will also allow an overall system check to ensure everything is functional. The precision of every optical tracking system is driven by the detailed information within the software concerning the camera geometry. This includes the distance of the cameras relative to each other as well as their relative viewing angles. The problem of any mechanical device is that the consistency of such data can not be guaranteed over a long period of time. The camera holder may be bent or bouncing with the camera against an object might change its calibration. To compensate for this problem, unlike any other system, the VectorVision system provides a calibration procedure to ensure the highest precision for every procedure. This calibration routine also

allows an added flexibility to change the inter-camera distance and angle of the cameras relative to each other should this ever be desired in the future. This provides more options for specialized camera attachment. The calibration procedure is conducted using the calibration tool for calibration. The necessary steps for calibration after turning on the VectorVision computer are described later. The configuration of the cameras is stored on the computer hard disk, so that this calibration doesn't necessarily need to be repeated prior to every procedure. Remember the recalibration isn't necessary if the two cameras are moved together as a fixed unit. Recalibration is necessary, however, if the cameras have been moved relative to each other in any way.

Whenever the calibration dialog box appears on the screen, the user may either keep the stored calibration from last time and select **Cancel**, or carry out the calibration. Even before loading image data from the first patient, you may select:

Camera Calibration from the **Settings** pull down menu.

The cameras should be adjusted symmetrically and their apertures should be adjusted to 5.6 - 8 and the focal distance to ∞ (infinity). Remove the sliding camera housing on top to get access to the adjustment rings for aperture and focus. The cameras working rang is 0.5 - 2.2 m with an optimum distance at 1.5m.

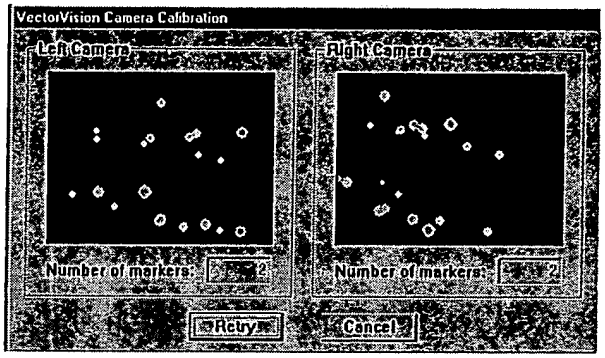


Figure 11: Camera Calibration Display

This function opens the dialog box with two black windows, each representing the separate images seen by the two cameras.

Left Camera represents the image taken by the camera, which is mounted on the left-hand side when facing the camera. **Right Camera** represents the camera on the right-hand side.

Reverse cable connection

In case that the camera cables are connected in reverse to the video controller, the software will recognize it during calibration and put the views right.

How to use the calibration tool

All markers detected by the cameras are represented by green dots. Below each window, the number of markers detected is displayed. Before you bring the calibration tool into the view of the cameras, all other objects, causing reflections and seen by the cameras should be removed. Place the calibration tool at a distance and angle to both cameras so that it is near the center of both camera views and takes up about 50% of the size of the window. It is also important, that the calibration tool be located in a way that all markers can be seen as separate circles. They should not get too close to each other in any of the views. Otherwise, two markers may be recognized as one marker. You can easily control that by watching the number of markers displayed in the lower part of the dialog box. It should be two for both views.

Reflections If the calibration is rejected several times due to environmental reflections, then cover one of the markers on the calibration rod, move the tool in the cameras field of view and wait some seconds until the cameras' aperture has adapted to the reflectivity of the one visible marker sphere. Then uncover the second sphere again click **Retry** button in the calibration window.

! CAUTION

Artifacts caused by reflections may result in a poor accuracy.

Calibration procedure When both cameras have a proper view, start to move the calibration tool around in horizontal and vertical circular movements in what will be the operating area. The system will automatically sample ten (10) different positions of the calibration tool and confirm each sample with a beep. The trace of the tool will be indicated as gray dots. Try to use the whole viewing area of the cameras to achieve the best calibration results. This can be controlled easily by watching the tools' trace. In the lower screen bar the number of already accepted sample positions is displayed. As soon as all ten required positions are sampled successfully, the monitor will display in the lower screen bar the achieved accuracy of the markers and the optimum operating distance. The software will then process all the information acquired during this procedure.

Calibration accuracy The calibration is successful if the achieved accuracy is at least 0.30 mm. Otherwise you will be requested to press the **Retry** button and start over.

After this calibration is done during set-up of the system, it usually is not even required to select calibration anymore.

CAUTION

Please note, that the slice increment and the slice thickness in the vertical scan range that contains the blue CT marker spheres should not exceed 3 mm. It is even recommended to use 1.5 or 2 mm, if a scanner with a reasonable speed and throughput is used.

Patient preparation

For referencing a patient's anatomy to the diagnostic data sets, the software can achieve a correspondence based on three types of registration.

- a stereotactic headring,
- artificial landmarks fiducials attached to the patient, usually on the skin, or
- anatomical landmarks.

Stereotactic headring

The use of a stereotactic headring as a reference is described later on in this manual. The use of artificial landmarks (skin fiducials) is now described in detail in this chapter. Our experiences have shown that for cranial work, anatomical landmarks such as the nasion, inion, or ear canals are too big and vague in location to provide the desired precision for this type of procedure. The support of this alternative hasn't been implemented.

Anatomical landmarks

Much better success has been achieved with small artificial landmarks because their position can be defined so much more precisely. The two basic alternatives considered during development were either invasive or non-invasive markers.

Non-invasive markers

Because our experience, as well as published clinical data from other groups, indicate that non-invasive markers are adequate to achieve acceptable accuracy, the following description is based on the assumption that non-invasive markers provided by BrainLAB are used. Please note, that other third party invasive markers that are cleared by the

FDA may also be used. Since there is very little or no difference in how the further task are performed regardless of the type of alternative marker used, they will not be specifically mentioned. BrainLAB provides white plastic sockets, which are adhesive and may be stuck to the patient's skin. Those markers should be positioned at orientations where there is very little skin movement of the patient and which are located not too far away from this surgical site. Please take into account also that one needs to be able to identify the sockets with the pointer tool in a way that the tool is visible to the cameras at the time the patient is positioned in the operating room. It is also desirable to have the markers not in a straight line. Rather, they should form an irregular triangle with the surgical target area being close to the center of the triangle. Also, the distance between the patient markers should be larger than the distance of the markers to the surgical target.

No. of markers

It is also recommended to place more than three markers on the patient. The software only requires the use of three markers, but the use of additional markers provides more choice in case one of the markers is obstructed or becomes displaced during the scanning or positioning.

Signing the marker positions

It may also prove helpful to mark the position of the skin marker base by a circle with permanent ink. This will allow the skin marker to be replaced accurately in case one is dislodged completely. In the future, the sockets will possibly become available as a disposable item in order to simplify the procedure.

How to place CT/ MR marker

To achieve a high accuracy it is crucial to place the markers in the following way. 2 to 3 markers should be placed in the plane of the area of interest. This means on the same CT/MR scan as the tumor, or the area of interest. 2 markers should be placed above or below this plane. It should be considered that all marker positions should be accessible during referencing in the OR and should not be shifted or pressed during the scanning procedure. The markers should be placed on areas with little skin shift. Always consider that the system can only compare the CT marker positions with the real Marker positions during referencing. If there is a deviation, an algorithm will try to

improve the overall accuracy and minimize any error. But the best accuracy can only be reached when minimizing the skin shift from the very beginning in taking considerations about where to place the CT/MR markers.

CT/MR- and patient-marker handling

Together with the marker sockets, blue 8-millimeter aluminum solid spheres, spheres filled with MR visible material and indented spheres are provided. Each CT/MR solid sphere used during the CT or MR scanning is removable from the base with the help of a grip tool (enclosed in the CT/MR marker set) and interchanged with an indented sphere whose center can be touched accurately during the registration procedure later in the operating room. Each sphere, solid or open can be pressed into the socket and will be accurately held in a defined position. After all sockets have been filled with the solid spherical markers, the patient is ready for the CT-examination. To interchange a sphere utilize the grip tool.

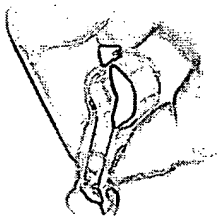


Figure 12: Grip tool for interchanging spheres

CT-Scan

There are no special or unusual requirements for the CT-examination. The zoom factor should allow all skin markers to be visible and the slice thickness should be as thin as practical. As typical for any 3-D reconstruction work based on diagnostic data, neither the table height, nor the zoom factor, the field of view, the gantry tilt or any other parameter except the table position should be changed once the scanning in the diagnostic examination has actually started. In case any adjustments are required after the first scan, the previous scans should be either deleted or a completely new series should be started.

Scan range Presimulating the entire craniotomy it is also recommended, to scan the full vertical range of the patient. If only the target area is shown in the diagnostic data, specific planning of the craniotomy may not be possible.

Data Pre-processing The first step in preprocessing the patient data is to transfer the data into the VectorVision system. Follow the instructions of the manual for data transfer. Next open the patient file and check if all images have been properly transferred. The best menu selection to get an overview of the entire range of images is with the catalog function on the right hand side of the screen.

It may also be important to adjust the windowing (from the **Settings** menu at the top of the screen) to the specific diagnostic requirements of that particular patient. Next, use the draw functions, in conjunction with the automatic contouring features, if available, for defining any volumes of interests.

If MRI-data is available for the same patient, use the image fusion function to correlate the MRI-data with the CT-data acquired with the patient markers. One possibility for simplifying the procedure is to identify structures before hand based on the MRI image. Those structures will then also become available for the CT-images based on the reference provided for the image fusion. After the structure definition has been completed, the display should be set up in order to provide the most helpful information during the surgical procedure.

In case MRI-images are being used in conjunction with the CT-images, switch to the axial MRI-images and select other views to display the coronal and the sagittal view at the bottom of the screen. Otherwise call up a coronal and sagittal reconstruction based on the CT-images. It is also recommended to set up the desired parameters for a comprehensive 3-dimensional representation. You may use the options provided in

the **3D Parameters** dialog box from the **Settings** menu. If you have done this once, you can easily toggle between a 3-dimensional and a single scan image representation by only selecting one radio button. The better the set-up of the display is planned before hand, the less user interaction with the software will be required once the actual surgery is underway.

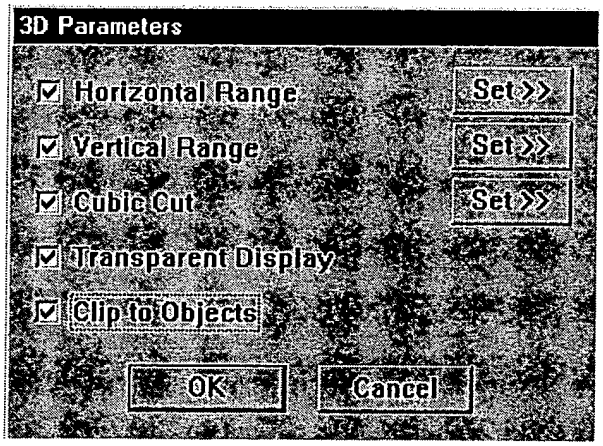


Figure 13: 3D Parameters

Markerbased Image Fusion

VectorVision provides the possibility of fusing CT and MRI scans based on the described CT/MR markers automatically.

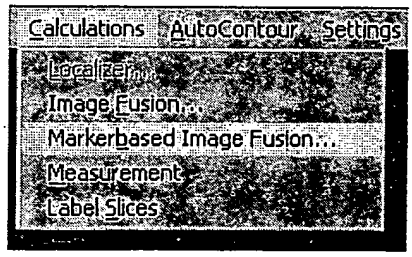


Figure 14: Markerbased Image Fusion

Select **Markerbased Image Fuision...** from the **Calculations** pull-down menu.

Please note that VectorVision currently supports only T1-weighted MRI scans for markerbased image fusion. The half-automatic image fusion of T2-weighted MRI scans with CT-scans is described in the section **"Basic Software Functions"**.

A dialog will open, which allows to determin which CT and MRI set shall be fused.

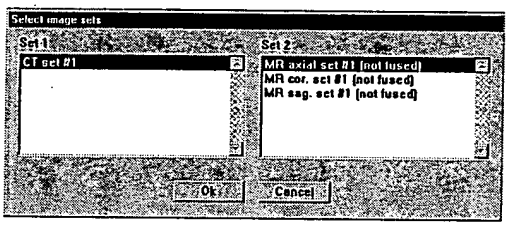


Figure 15: Select image sets dialog box. Set 2.

After the selection is confirmed with **Ok** the software will try to detect the CT and MR markers in each set and fuse the sets.

If the fusion is successful the software will prompt following message box informing about the accuracy of the performed fusion.

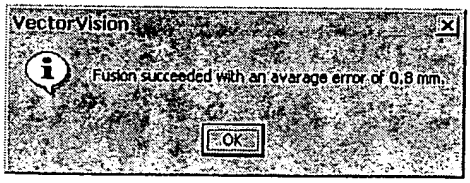


Figure 16: Successful Markerbase Image Fusion

In case the fusion fails due to insufficient number of detected corresponding markers the software will prompt this message box.

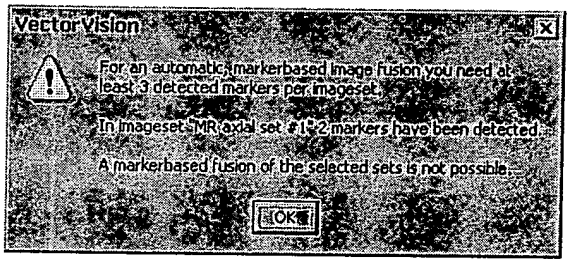


Figure 17: Failed Image Fusion

Thresholds for Marker Detection

In some case it might be necessary to adjust manually the thresholds for detecting the CT/MRI-Markers automatically. These settings depend strongly on the setup and calibration of the used CT and MR scanner.

For adjustments select the tab **Marker** from the **VectorVision Settings...** menu.

There the thresholds and accuracy for the automatic detection can be entered for MRI and CT.

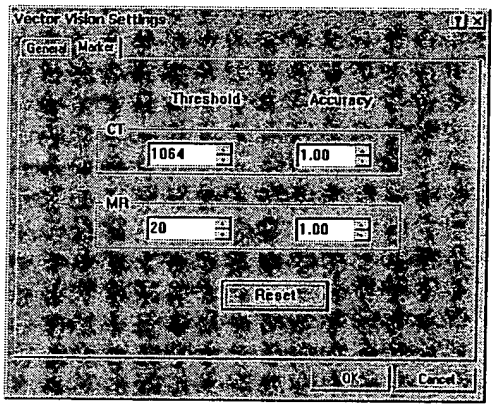


Figure 18: Adjustment of thresholds

Threshold & Accuracy Relation

Some CT scanners cut off Houndsfield values above 1000 or 1500, what means that the marker spheres appear in the images as bones and are hardly to separate in their density from bony structures. Thus, the threshold shall be adjusted to ca. 1000. Now, the software will try to detect the markers by their density from 1000 on. The second criterion for a reliable automatic detection is the circular shape of the markers. The accuracy value determines the "circularity" of a marker A value of 1.0 represents a regularly shaped sphere, larger values allow the detection of irregular circular shapes. Values up to 3.0 are sensible. If the scanner limits the bone window as described, then a

value of 1.0 shall be adjusted to restrict the detected shapes to spheres.

For normal calibrated scanners a threshold of ca. 2000 and an accuracy of up to 3.0 can be admitted, as then the density of bone and markers can be easily separated.

The same criteria are also valid for MRI scanners.

Trajectory Planning

Pre-planned trajectories for the approach to a lesion are often a useful guidance tool to the surgeon during the procedure. These trajectories can also be used in combination with a microscope and can also be modified intraoperatively. Please refer to the chapter "**Stereotactic Planning**" for a detailed description.

OPERATING INSTRUCTIONS

PATIENT REFERENCING

PREPARATIONS

Exchange of patient markers

The blue solid marker spheres, secured to the marker sockets during CT-examination need to be removed and to be replaced by the open spheres with an cone to the center at this stage of procedure. This enables the surgeon to precisely identify the center of the CT-marker position with the pointer tool later. Open sphere referencing markers are mounted to the sockets in the same way as the solid spherical CT-markers.

Draping

After the scan data has been preprocessed and the patient anesthetized, the Mayfield headrest is applied in a way that there is as little Marker movement as possible and the patient positioned as desired for surgery. The intended surgical field is cleaned and prepped for surgery. The next step is to create a reference between the patient's anatomy as positioned and the diagnostic data within the computer. Start draping one side of the patient where the Mayfield Reference Clamp is to be mounted.

Mayfield marker array

Next, position the Mayfield Reference Clamp with the extension on the Mayfield headholder. The marker array has three marker spheres and an adapter which mounts on any side of the Mayfield headholder. Simply place the adapter with the three markers so that the reflective markers point towards the cameras. It is important that the reflective markers can be well detected by the cameras. The marker array can be moved when loosening the angular adjustment screws (see Figure 4). The fixation nut should always be tightly fixed when a the extension is mounted.

! CAUTION

Please ensure a tight secure fit of the Mayfield marker array on the headholder because any movement of the marker array relative to the headholder during the case will result in a localization error later during the procedure.

Adjusting the camera array

The next step is to adjust the camera array's position so that the cameras view the operative field and the Mayfield marker array in as perpendicular a way as possible. The cameras later will need to see all three markers with as much separation as possible between them. Only the entire array may be moved, because if a single camera is moved (relatively to the other one) camera calibration gets lost.

Mayfield Marker consider-ations

Please evaluate the position of the three marker array on the Mayfield, considering that they need to be visible for the cameras all the time during the procedure. They will provide the coordinate system for the procedure and will enable the dynamic referencing to the patient position. As long as the patient's head, the Mayfield headholder and the Mayfield reference marker array are moved together as one unit, there will not be any effect on accuracy of the localization functions during the procedure. Similarly, under these same conditions, it will also be possible to move the camera array without effecting the accuracy of the surgical guidance.

⚠ WARNING

Do not:

- **adjust or move a single camera (relatively to the other one)**
- **move the Mayfield Marker Array relatively to the patient's anatomy**

during later procedure!

In both cases the entire measurement coordinate system would be improperly affected. This might lead to wrong tool tip display.

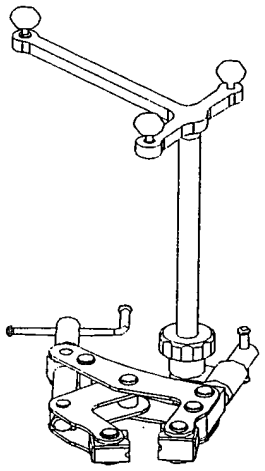


Figure 19: Mayfield Reference Clamp

Please refer to the corresponding chapter of this manual about the Mayfield Reference Clamp for additional information.

VECTOR VISION

Surgery Planning Cranial

After the patient images are transferred to the VectorVision Workstation you can start with the **Surgery Planning** for the optimal surgical approach. After the lesion is outlined you can set the **Target-** and **Entry Point**. By using **Probeview** it's possible to have a look of the way of the trajectory. More information about the **Surgery Planning** see in chapter "**Stereotactic Planning**".

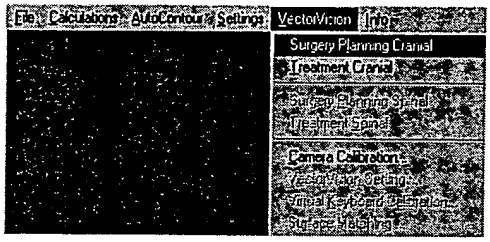


Figure 20: Surgery Planning Cranial

Treatment Cranial

From this point on, it is assumed that the patient imaging data has already been loaded in the computer and the display prepared as described in the chapter above. Now select **Treatment Cranial** from the **VectorVision** menu in order to start.

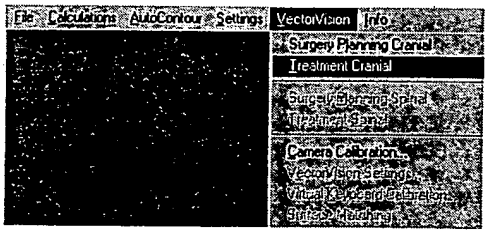


Figure 21: Treatment Cranial

LABELING FUNCTION

Label Slices After loading patient data the user is able to set labels for anatomic structures e.g., vertebrae, for a range of his choice. He is able to switch between a coronal or sagittal reconstruction and to determine the range by two lines in the reconstruction. Now select **Label Slices** from the **Calculations** menu in order to start.

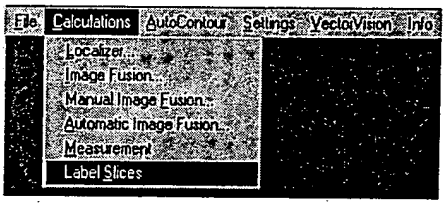


Figure 22: Label Slices

After starting Label Slices the following box appears.

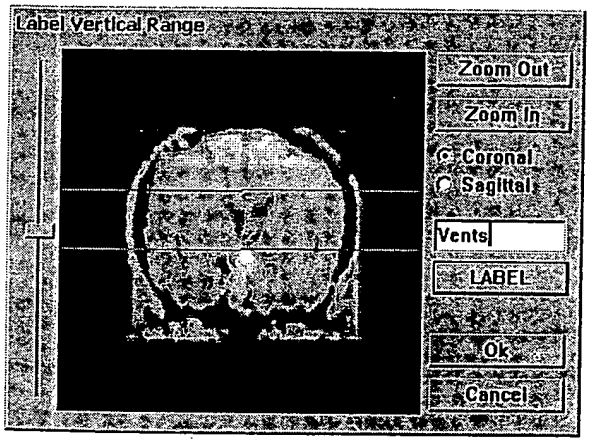


Figure 23: Label Slices menu box

The slide bar allows the user to leaf through the image set in the chosen reconstruction. By clicking the Coronal button the Coronal reconstruction is enabled and displayed; by clicking the Sagittal button, the Sagittal reconstruction is enabled and displayed. The horizontal lines determine the range of the label and appear blue. If they are touched with the left mouse button they turn yellow and can be dragged with the hold down the left mouse button to set the start and end point of the range. The upper line can't be dragged over the lower line and vice versa. Now click in the text box with the left mouse button and determine the section via keyboard. After clicking the **Label** button, the label name in the text box is assigned to the range, which is adjusted by the two horizontal lines in the display. By clicking the **OK** button the procedure is finished and all entered labels are assigned to their appropriate axial scans. The Cancel button finishes the procedure and all entered labels are dismissed and don't appear in the axial slices. The Zoom In/Out function may also be utilized to Zoom In or Out if necessary. The entered labels are displayed in the upper right corner of the assigned axial slices. This is required for 1, 4, 9 and 16 images.

PATIENT REFERENCING ALTERNATIVES

The appearing menu box allows you to choose between different registration modalities:

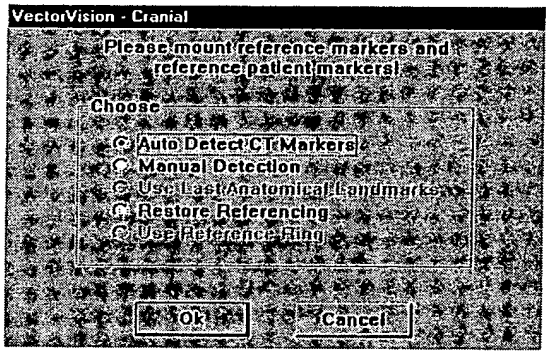


Figure 24: Registration menu

Auto Detect CT Markers This option is enabled by default, as it is the usual method for patient registration. The software detects automatically all attached CT-markers from the CT-image set and prompts then the user to register the patient markers in any order.

Manual Detection Instead of using CT- and patient markers also anatomical landmarks can be utilized to perform patient registration. This dialog box enables you to select three to seven patient markers or artificial or anatomical marks in CT-data that may be later identified on the patient. After clicking the "Set Landmark" button you can either set the first landmark or drag an already set anatomical landmark in all possible windows (scans, reconstr. 3D reconstr.,...) by clicking there with the left mouse button and confirming it with the middle mouse button. When a mark is set in one of the windows, then its according position is displayed in the other enabled windows. Landmarks set in the 3D display are automatically snapped to the surface. If "Automatic Update" is enabled

in the Display Parameters of the **Settings** pull-down menu, then the according cut of the reconstruction are displayed. After clicking the "Add new" button you can set an additional landmark as described before. The new markers have a different color and the new marker color and number are incremented in the lower list box. By clicking the "Remove" button the actual landmark is deleted. It is also not required, or even desirable that all seven markers are located on the same CT-slice. After this has been completed, select **Ok**. But, do not set landmarks in different unfused images sets. If you want to do so, then fuse them first.

Note: As long as the marker position is not confirmed with the middle mouse button, no other landmarks can be moved or dragged.

Referencing markers

To set a reference point, move your pointer to the desired location and fix the tip at this point. A slow movement with the end of the pointer while keeping the tip at exactly the same position for more than 2 seconds triggers the system to take this point as a reference point. The pointer should be perpendicular to the marker socket to avoid any skin shift caused by the force of the pointer. Any point that is acquired in this way will be taken as a reference point. If you use automatic CT/MR marker detection and you accidentally acquire a point that was not specified as a marker, the software will automatically prompt you that a marker could not be matched and return to the manual referencing procedure.

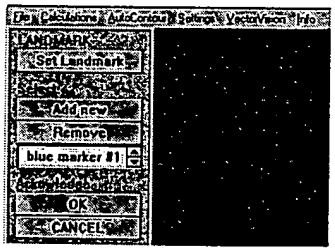


Figure 25: Setting anatomical landmarks

Use last anatomical landmarks If you want to repeat a manual registration due to insufficient accuracy at the first attempt, then repeat the registration with the same landmarks by choosing this menu item.

Accuracy of referencing The VectorVision system calculates the achieved accuracy of referencing and displays it at the bottom bar. If the achieved accuracy exceeds 5 mm, the following message box will appear. We recommend retrying referencing in order to achieve better accuracy.

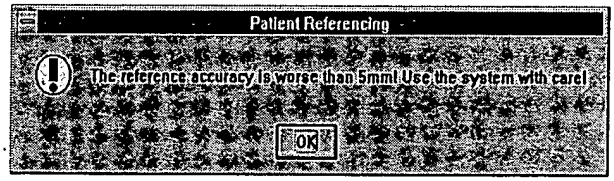


Figure 26: Bad Accuracy Warning

WARNING

Use the system with care if the accuracy warning appears.

Restore referencing The **Vector Vision** software stores automatically the last successfully performed patient registration on the hard disk.

WARNING

The Restore function resumes the position of the last known fiducials relative to the Mayfield Reference Clamp. Make sure that the patient has not changed his position relative to the reference clamp. An additional message box will request you to check the fiducials again before proceeding.

This feature is very useful in case of a power failure or for leaving and re-entering the VectorVision mode, e.g. to plan a trajectory, without the need to perform patient registration from the beginning. The following message box will then appear to confirm the accuracy:

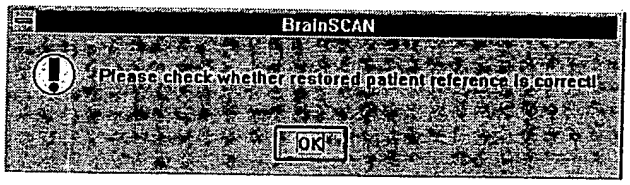


Figure 27: Checking restored patient reference

Click **Ok** and touch the fiducials or anatomical landmarks with the pointer and verify that the pointer tip is displayed at the corresponding, correct location.

Use reference-ring

If a stereotacticaly prepared patient is treated, e.g. wearing an invasive headring with a localizer box, then use this menu item. Further registration is not necessary, once the localizer has been identified.

After a registration mode has been chosen, a dialog box prompts you to mount the reference markers on your Mayfield. When this has been done following the description written above, simply select the **Ok** button. Next, follow the prompt at the bottom of the screen.

Pointing to markers

Next you are requested to identify the marker positions on the patient by touching, in sequence, each open center of the red skin mounted patient markers with the pointer tool. This tool is bayonet style with two reflective markers on the handle. When touching the marker centers, hold the pointer tool so that its two marker spheres are aligned as perpendicular as possible to the cameras viewing angle. The greater the separation of the marker spheres as seen by the cameras, the better the accuracy. Also, when holding the tool to the marker, move the handle slightly while keeping the tip fixed at the marker center. This helps the software identify the tool and marker positions more quickly.

! CAUTION

Artifacts caused by reflections especially during referencing can cause insufficient accuracy. Please verify that all items which are highly reflective or light sources do not disturb the camera view.

Anatomical landmarks Anatomical landmarks are identified the same way.

! CAUTION

If you use anatomical landmarks, then identify the landmarks according to the sequence you determined in the CT-scans. Otherwise the reference will not match the anatomical conditions.

"Drill-Hole"-Referencing This referencing alternative serves as a backup registration. It can be applied only during navigation, i.e. for already registered patients.

For this referencing method small drill holes (min. 3) are made around the craniotomy. These drill holes are later used as anatomical landmarks. Then choose **Acquire Landmarks...** from the **VectorVision** menu. A message box indicating that all previous landmarks will be deleted will appear. If you click **Ok** to proceed the following box will appear.

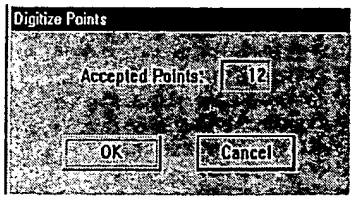


Figure 28: Acquireing landmarks during procedure

This box counts the number of landmarks (drill-holes) you are going to acquire. Touch now with the pointer tool the drill holes in any order. Each hole will be confirmed by a signal and the counter will be incremented. As soon as all markers have been acquired click the **Ok** button. Now the software has memorized the drill holes as new anatomical landmarks and you can continue normally with the procedure.

If re-registration becomes necessary during procedure then these landmarks are used for registration. Leave the VectorVision mode and re-enter it again. The software will prompt you again as described in Figure 24. Choose **Use last Anatomical Landmarks** to continue or **Manual Detection** if you want to edit the landmarks before you continue with registration. The further process is straight forward as for registering anatomical landmarks described earlier. We recommend also to save the new acuired land marks as a new plan. So, that plan with the saved landmarks can be used even after power failure in the OR. Otherwise the landmarks may be lost.

Confirming registration

The status window will turn blue and an audible "beep" will confirm the registration of a particular marker. After the marker location is registered with the software, you may proceed to the next marker. Again every marker will be confirmed by blue status window and an audible beep.

Please note, that you may identify any of the patient markers in any order. You may even identify the markers twice. This allows you to skip patient markers that are not reachable or have fallen off. But at least three different markers must be identified.

Accuracy check

As soon as the registration is finished the following message box will request you to check the registration. Touch the fiducials or anatomical structures on the patient for this purpose. Otherwise, repeat the registration as described before.

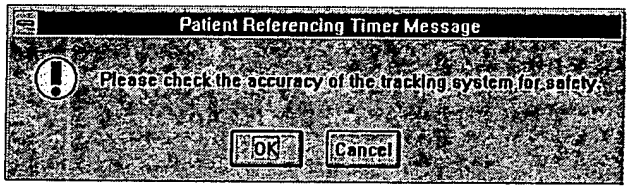


Figure 29: Checking of the accuracy

This message will appear periodically every 30 min. to check the accuracy also intraoperatively.

Camera view

After clicking **Ok**, you may watch some of the information provided at the left-hand side of the screen. The two small windows indicating the view of each camera should each indicate three red colored dots that belong to the Mayfield reference marker array. If there are not three red Mayfield array markers visible in each camera window while touching each open blue patient marker with the pointer tool, the referencing is not possible. The two markers of the pointer tool will be represented in green. If the dots that belong to the pointer do not turn green, you have either obstructed one of the reference markers, or the two markers of the pointer may not be fully visible for both cameras. In such a case slightly move the pointer and check again. There also may be problems if you are too close to the border of one of the camera pictures. In such a case, move the cameras slightly further away or rotate the camera arm in order to bring the object back nearer to the center of the image. Please also watch the coordinate of the tip for the tool position at the left-hand side of the screen. This will enable you to detect any movement made with your point tip.

CAUTION

By watching the coordinates as you move the pointer, you will notice, that the precision of measurement in a plane perpendicular to the viewing direction of the cameras is higher than the precision available at other points within the camera access. It is recommended to take this into account when positioning the patient, so that the highest precision is provided in the dimension where it is most required.

Repeating registration If you want to select other patient markers you must leave the **VectorVision** mode by selecting **Treatment Cranial** from the **VectorVision**menu. You can start over by calling **Treatment Cranial** again, which enables you to repeat again with marker positioning and marker identifications with the software as described above.

Brainshift In case of major brainshifting, you may also reenter the **Treatment Cranial** mode to update the reference using any visible internal landmarks closer to your target area. This might result in larger error anywhere else in the brain, but will achieve a higher accuracy in your target area.

CAUTION

Brainshift may cause a difference between preoperative patient data and the actual position on the patient.

Denied markers If the identified markers and the CT/MR-detected patient markers do not fully match, the software will deny them as a reference and return to manual patient referencing. This might be caused by insufficient resolution of the CT-image, by a displacement of the patient markers due to skin movement, by too thick CT-slices or other factors. In such a case. Now markers which have obviously shifted can be deleted and the referencing procedure can be started again. You can also leave the **Treatment Cranial** mode and restart it to redefine the markers or to select other

markers or use **Manual Detection** from the **Treatment Cranial** mode of the **VectorVision** menu.

After referencing the patient markers, the software is able to track the surgical distance to the anatomical structures and display the tool position in the computer display through a green line accordingly.

Vector Vision Settings

In the **VectorVision Settings** from the pulldown menu **VectorVision** you can select additional options like 'Large tip cross' for easy visualisation of tip position and alter settings for CT/MR marker detection, Microscope, Thick instruments and video overlay. More information and how to use these tools see corresponding chapters.

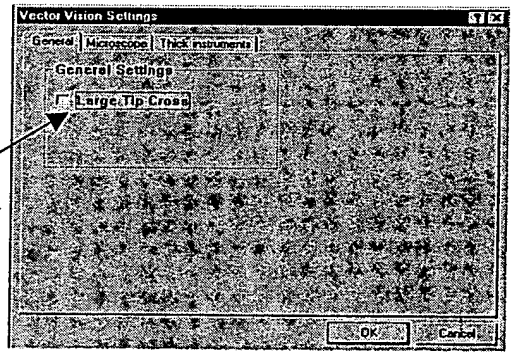


Figure 30: VectorVision Settings

SURFACE MATCHING

Surface Matching

The registration accuracy can be improved in some cases, especially when using anatomical landmarks, by applying a surface matching algorithm. This algorithm reconstructs a mathematical surface by means of digitized points on a surface and tries matching it to the real specific surface.

To perform surface matching the patient has to be already registered by anatomical landmarks or patient markers. Then select **Surface Matching...** from the **VectorVision** menu. Following message box will appear.

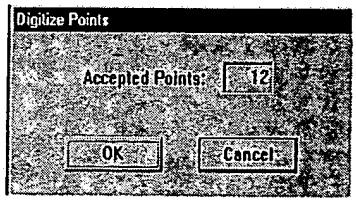


Figure 31: Surface Matching

You can ignore this box by clicking **Cancel**. For performance reasons we recommend to disable for surface matching **Autom. Update** or to enable **Freeze Slices**. The acquisition of surface points is done with the standard pointer tool by touching points on the patients head and pivoting the pointer slightly around that point. An acoustic signal and a blue status field confirm each registered point. The number of already digitized points is displayed in the message box and incremented with each new point. Until you reach the minimum number of registered points the **OK** button is gray and disabled. The minimum number of acquisition surface points is twelve.

After finishing the point acquisition by clicking the **OK** button another message box appears indicating the calculation process. By clicking the **OK** button the function **Surface Matching** is completed.

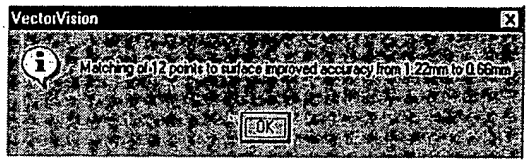


Figure 32: Calculate Surface Matching

If the surface matching algorithm could not improve the accuracy then an according message will appear instead.

VIRTUAL KEYBOARD

Virtual Keyboard Calibration

The Virtual Keyboard is an optional metal plate with an engraved set of functions for easy and quick software control. It can be mounted to the Mayfield Headsrest in a identical way as the Mayfield Reference Clamp.

The Virtual Keyboard needs to be referenced before it can be utilized.

Mount the sterile virtual keyboard on one side of the Mayfield Headclamp and fix it tight. Enable the function **Virtual keyboard calibration** from the **VectorVision** menu. You will be prompted to reference the virtual keyboard. Then you can acquire the three reference points on the virtual keyboard in any sequence.

! CAUTION

If the virtual keyboard is fixed more than 30cm away from the reference clamp it may be difficult to reference due to a lack of accuracy.

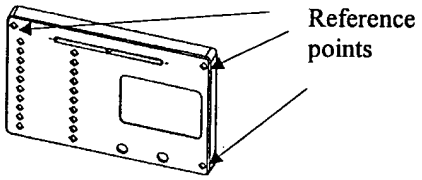


Figure 33: Virtual Keyboard with marked reference points

Customizing the Virtual Keyboard

The Virtual Keyboard provides five cones (Function A-E), which can be freely configured. Select the according tab from the **VectorVision Settings** tab box in the **VectorVision** menu.

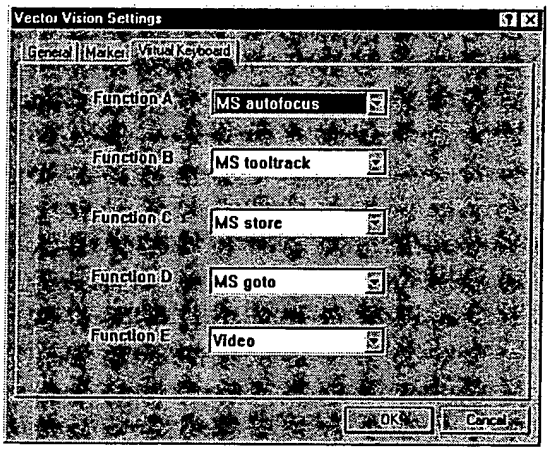


Figure 34: Customizing the Virtual Keyboard

This tab box enables the user to map a function (out of all available functions) to a button (A-E). Selection is done by clicking on the combo boxes, that contain all available functions of the Virtual Keyboard.

OK acknowledges the selection, **Cancel** discards it.

The changes take effect in the next navigation session.

DISPLAY OPTIONS

DISPLAY SETUP

The Function **Display setup** is located in the menu **Settings**.

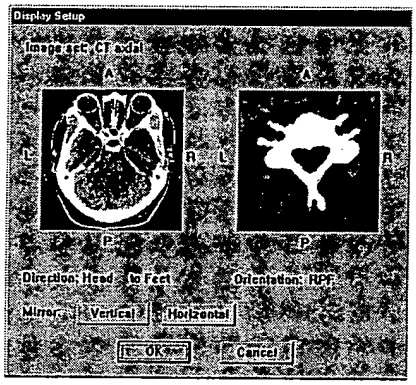


Figure 35: Display setup setting box

Display Orientation

The display setup can be used to rotate the axial image horizontally or vertically to synchronize the image display setup with the actual patient setup e.g. patient is being treated from feet to head, therefore the display can be synchronized to be feet to head, too.

When clicking the **Vertical** button all images will be turned in vertical direction. E.g. anterior is being displayed at the top of the screen when clicking **Vertical** anterior will be displayed at the bottom of the screen. The line of site is also being turned e.g. from 'head to feet' to 'feet to head'.

When clicking the **Horizontal** button all images will be turned in horizontal direction. E.g. left is displayed on the left side of the screen when clicking Horizontal right will be displayed on the left side of the screen. The line of site is also being turned e.g. from 'head to feet' to 'feet to head'.

The current orientation is displayed on the screen. There are 4 different possibilities:

RPF = Right side is displayed right; Posterior is displayed at bottom of screen; Line of site is from head to Feet.

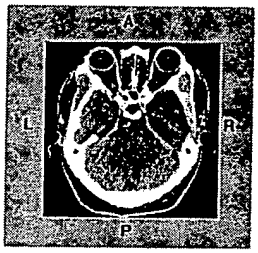


Figure 36: RPF orientation

RAH = Right side is displayed right; Anterior is displayed at bottom of screen; Line of site is from feet to Head.

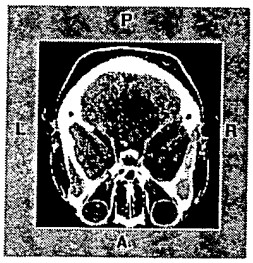


Figure 37: RAH orientation

LPH = Left side is displayed right; Posterior is displayed at bottom of screen; Line of site is from feet to Head.

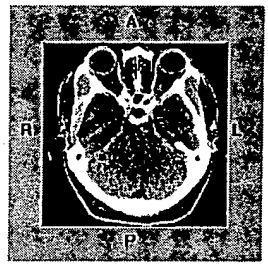


Figure 38: LPH orientation

LAF = Left side is displayed right; Anterior is displayed at bottom of screen; Line of site is from head to Feet.

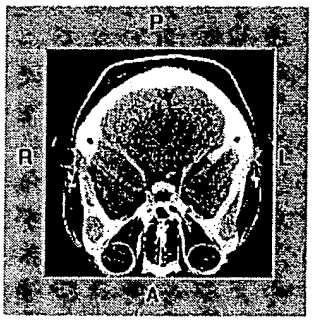


Figure 39: LAF orientation

CAUTION

The display setup can only be changed on an initial plan where there are no alternations being processed. Once a structure is being outlined or a trajectory is being planned, the display setup function will be disabled.

Further, we recommend to save the setup display as a plan to be able to restore referencing if necessary.

WARNING

Always check that the display setup is according to your needs. The initials in the left and right lower corner of the axial image is always displaying the right-left orientation.

TOOL TIP

The section "Tool Tip" is located at the top of the left hand side and appears after selecting the **Treatment Cranial** mode. The functionality is described in detail below.

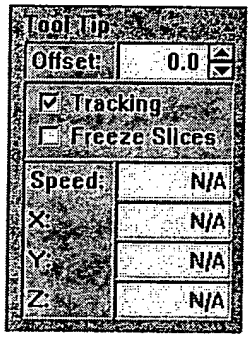


Figure 40: Tool Tip

Offset

As long as the text button offset displays zero, the software will always show the position of the tip of the currently used tool. For simulating a procedure, it may be helpful to virtually extend the tip to see ahead, or deep to, where you currently are. This can be helpful, for example, in planning the location of your craniotomy for a lesion located at the surface of the brain. If you extend your tip about 10 mm and move over the patient's skull, you can see in the **Depthview** display (see corresponding description) if the lesion is below the current point tip or not. This feature enables you to interactively move to the point where you just hit the border of the lesion, based on this information you can outline the position of the lesion on the skull in this way minimize the craniotomy size.

If you increase the tip offset to a value greater than zero, the tip extension will be represented in red. Values smaller than zero are represented in gray. Furthermore, the values are highlighted in red.

CAUTION

After working with a different offset, do not forget to set it back to zero, to avoid misunderstandings. So be always aware when the tool tip offset is set to a value different than zero.

WARNING

If you are using instruments with mounted tool adapters, be aware that the instrument trajectory is determined by the instrument tip and the central cone of the adapter and not by the center axis of the instrument. So angular errors can appear, if the instrument tip is extended.

WARNING

The reconstructions and all other views are being updated to the virtual tool tip.

Tracking You will notice, that all the axial slices and coronal/sagittal reconstruction in use are instantaneously updated with change in the position of your instrument. This in general is helpful for giving a good orientation on the position of your probe. If you have reached the target area or you want to freeze the display for whatever reason, deselect the **Tracking** check box. This will cause the software to remain on the same slices or reconstruction, and the position of the projected tool is frozen. Further every user interaction will switch of the **Tracking** button.

Freeze Slices By selecting **Tracking** and **Freeze Slice** all the axial slices and coronal/sagittal reconstruction are frozen when the Freeze Slice button was activated. The moving

of the Tool Tip is shown visual. (Advisable is to use the **Split Screen** mode and the **3D Display** from the **Options** menu).

Tool Position The three settings provided indicate the X, Y and Z-coordinates in millimeters and the motion speed of the instrument in mm/s in the systems internal coordinate system. This enables you to check the repeatability of certain localization data and also makes it easy to monitor how steady you hold the pointer.

Note: If the microscope function is enabled, then this display is replaced by the microscope functions menu except the speed reading.

CAMERA DISPLAYS

General The camera displays provide continuous information on how the markers are seen by the cameras and allows the surgeon confirm the identification of the various objects used. The Mayfield reference marker array and Headring are always displayed as red dots, the pointer tool as green dots, other tools as yellow dots, the microscope marker array (if in use) as orange and non identified objects as gray dots. Markers, which are visible to only one camera as well as reflections of other materials, are displayed as gray hollow circles.

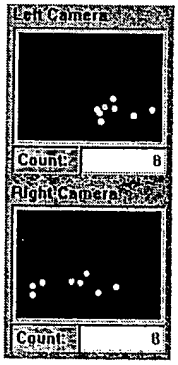


Figure 41: Camera Displays

Status Field

Also, the number of markers seen by each camera is indicated underneath the display. The status field below the camera views indicates if the reference markers and some additional surgical tools with a valid tip are fully visible and identified by the software. In such a case, the status field is green. If the markers attached to the Mayfield head-holder are obstructed from view by one of the cameras, then a yellow status field will indicate that navigation can only be properly performed as long as the patient and the cameras are not moved relative to each other. So we advise the user to establish immediately free view of the cameras to the Mayfield markers. If the tool is hidden the status also turns red. After 30 sec. of yellow status the field will turn red and indicate that navigation is no longer possible. This field is designed to give a quick idea during the procedure if the position of the instrument currently displayed is valid. The successful referencing of a patient marker is indicated by a blue colored status field.

Note:

If you use different unfused image sets, then navigation is only possible in the image set used for patient registration. When switching to a different unfused image set during navigation, then the new image set will be displayed, but no navigation in this image set is possible.

Navigation after switching the image set is only possible in fused image sets.

OPTIONS MENU

General Please refer to the section **"Basic Software Functions"** chapter **"Options Menu"** in this manual for basic information.

Modifications The Options Menu will show some modifications with **VectorVision** and will be accommodated interactively while you are proceeding. These modifications will slightly affect the functionality of the main screen displays according to the special needs of the neurosurgeon during procedure. These additional display features are described in detail below.

Depthview In VectorVision mode an additional display option will be added to the menu at the right hand side of the screen: **Depthview**.

By selecting this check box, an orthogonal reconstruction through the pointer tip is shown. This display might be one of the most comprehensive representations of the surrounding tissue in the area the probe is currently located.

In/Out The **In/Out** push-buttons zoom in or zoom out the activated reconstructions (sagittal, coronal, multiplanar).

Split Screen With the **Split Screen** mode (i.e. four equal sized display windows) activated, other display options are available as in the initial display mode. This is because in the split screen mode only three additional display windows are available, compared to four additional windows in initial mode. This means if you are switching from initial mode into **Split Screen** mode it may happen that one selected display is removed from the screen. The options menu is divided in two sections by a gray borderline in split screen mode (compared to three sections in initial mode). In the figure below it is explained where the options will be displayed on the screen and which options are available in each mode.

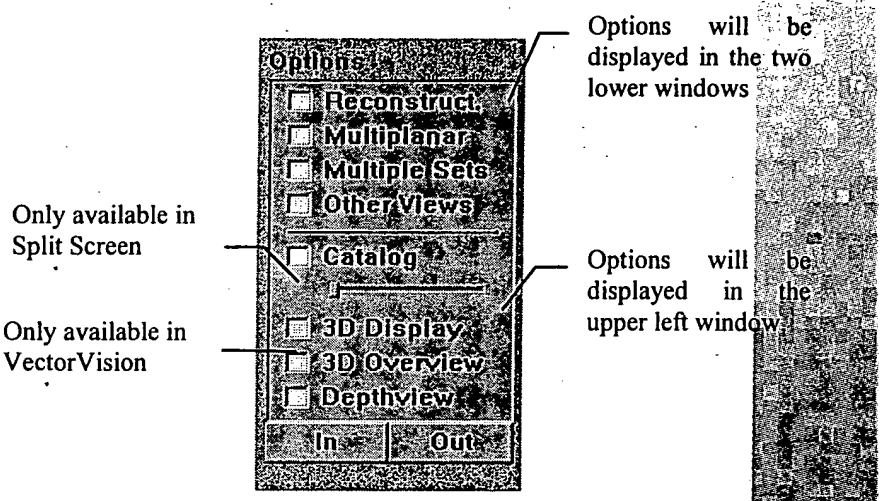


Figure 42: Options menu as shown in Split Screen mode in Treatment Cranial modus

3D Display This option is solely available in split screen mode and will display a three dimensional representation equal to that known from the main window and with the same capabilities. The only limitation is that the Zoom function is not available. For detailed information please refer to the section "Basic Software Functions" chapter "3D Display" in this manual.

The **3D Display** function of the **Main Window** controls is slightly modified when used during navigation. If enabled during navigation the view of 3D display is perpendicular to the curent pointer position.

2.5D Display

This special mode is a mixture of 2D and 3D display. That means that all outlined objects will appear as 3D objects overlayed to 2D images (axial view, reconstruction, depth view etc.) and provide the user with much better visual information of the size and boundaries of a lesion, as the 3D ojects are "depth coded". Parts of the objects which are in the reconstruction plane of the pointer tip appear solid and the rest of the object will appear semi-transparent. Even while approaching to an object or structure it is semi-transparent visible and helps in orientation.

USING A STEREOTACTIC HEADRING

As mentioned above, another means of reference between the patient's anatomy and the CT-diagnostic information may be provided through a stereotactic headring. In fact, this is the technique we provide to everybody who just gets started with neuronavigation. This is because this method incorporates equipment the user is already familiar with and reduces the number of new steps necessary. It provides the highest precision and enables further to become familiar with the art of using VectorVision while simplifying the technical steps necessary. Instead of using the adhesive marker as described above, a stereotactic headring is simply attached. Then the diagnostic imaging is conducted using the corresponding CT localizer. Next the patient is prepared in the usual manner for surgery.

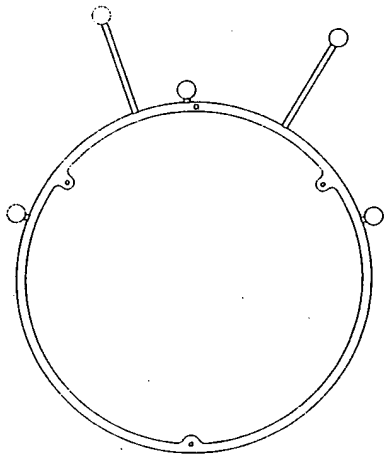


Figure 43: Reference Ring for Stereotactic Headring

Localizer Registration

When the images are transferred to the computer, make sure that the stereotactic system and localizer frame is identified in the transfer dialog window. After the patient image file is opened, the localizer function must be called

and the fiducials identified on one image. The software should automatically find the localizer frame fiducials on all the other images in the set. In cases where the software cannot identify a fiducial—as might occur if that fiducial is touching the skin of the patient's head--the window will prompt the user to manually identify the center of the ambiguous fiducial on the image with the mouse.

Draping

After draping the patient for surgery, the stereotactic reference ring for neuronavigation needs to be mounted to the stereotactic headring. This requires holes to be cut into the drape to enable the ball feet of the reference ring to pass through the draping into the locks of the headring. In case a BRW or BrainLAB headring is being used, the reference ring needs to be attached prior to the draping and the marker's spheres need to be guided through holes in the drape, so that they are visible for the cameras. Up to this step of preparation, the tracking of the surgical probe may start within seconds. No referencing steps are necessary on the part of the surgeon as long as both cameras see the marker arrays mounted to the headring. To do this, just enter the **VectorVision** mode by selecting **Treatment Cranial** from the **VectorVision** menu. Without any further calibration procedure, the probe may be used straight away for navigation. This is possible, because the software knows the absolute position of the markers attached to the reference ring within the stereotactic coordinate system. This provides a direct link between the patient's anatomy and the diagnostic CT-data. All other software functions are available now without any restriction just as after referencing using the adhesive markers as described earlier. The use of a stereotactic headring in any case provides the highest precision available. The only additional time required compared to a standard surgical procedure is the attachment of the headring and the diagnostic CT imaging with a headring and CT localizer frame on. With this exception there is no further delay to the procedure, while benefiting from the additional information provided by the 3D-tracking-system.

USING MULTIPLE TOOLS

Existing tools VectorVision enables you to continue using your existing surgical tools for navigation as usual.

Tool Adapters In addition, BrainLAB provides a variety of marker arrays and tool adapters, which are simply attached to your tools, e.g. a bipolar forceps or a suction tube, and allows you to navigate with these instruments instead of the pointer tool. This means, there is no need at all to purchase additionally any new proprietary tools or instruments for procedures with VectorVision.

Calibration After attaching the marker array to a tool, it must be calibrated to make the geometry of the tool known to the software. This is simply performed by holding the tip of the tool with the attached marker array into the small calibration cone in the middle of the Mayfield Reference Clamp. Just move the handle slightly while keeping the tip fixed in this cone and wait for an acoustic beep as confirmation. This tool calibration can be made either before starting the procedure or even at the moment before you want to use it during the operation.

CAUTION

To ensure a proper and precise tool calibration, we recommend the calibration cone be touched just before using each tool to avoid misjudgments due to improper handling of the tools.

WARNING

Exchanging a tool adaptor and using it on a different tool requires a new tool calibration.

Tool Direction Calibrator (TDC)

If you like to use a thick tool that cannot be referenced in the cone of the Mayfield reference clamp, BrainLAB offers a Tool Direction Calibrator (optional).

After the calibration of an additional tool the tool axis is determined by a line between the instrument tip and the center of the reference star, which usually does not correspond to the tool's real axis (see fig. below). Thus, BrainLAB provides the possibility to correct the calculated axis to the real axis by means of the TDC. The TDC contains a set of receptacles with different diameters of tools used frequently in practice. Additionally, a 30mm receptacle allows calibration of irregular shaped or very large tools.

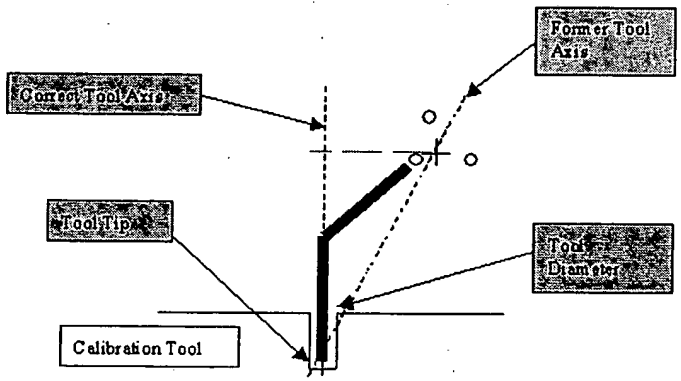


Figure 44: Correction of tool axis

Calibration of thick instruments

Before using the TDC, remove all other tools out of the view of the cameras.

Further, for calibration cover or remove the extension of the Mayfield Reference Clamp by opening the fixation nut and fix it back after you have finished.

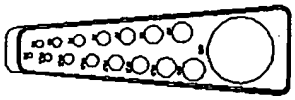


Figure 45: Thick instruments tool calibrator

Automatic Calibration

Yet registered instruments can be held into the corresponding receptacle of the Calibration Tool and are calibrated automatically. The system detects the calibration hole and adjusts the parameters for diameter, axis and tip. The marker array of the Mayfield Reference Clamp shall not be visible simulaneously with the marker array of the TDC.

No user interface is provided with this kind of calibration besides a message in the bottom bar, that indicates tool name and diameter.

Tool B has been calibrated with a diameter of 3.00 mm.

Manual Calibration

For manual calibration a dialog box is provided. It can be reached under the **VectorVision** menu item and is called **VectorVision Settings...**

Use the tab **Thick Instruments** to enable the dialog box.

This dialog box enables the user to enter the value for the tool diameter and to start the calibration procedure. If the user does not select a specific diameter, calibration is not possible.

To start the calibration procedure it is necessary to place both TDC and the instrument equipped with a reference star within the field of view. Otherwise, the **Calibrate...** button is not enabled and the calibration procedure cannot be started. But, remember that the marker array of the Mayfield Reference Clamp shall not be visible simulaneously with the marker array of the TDC.

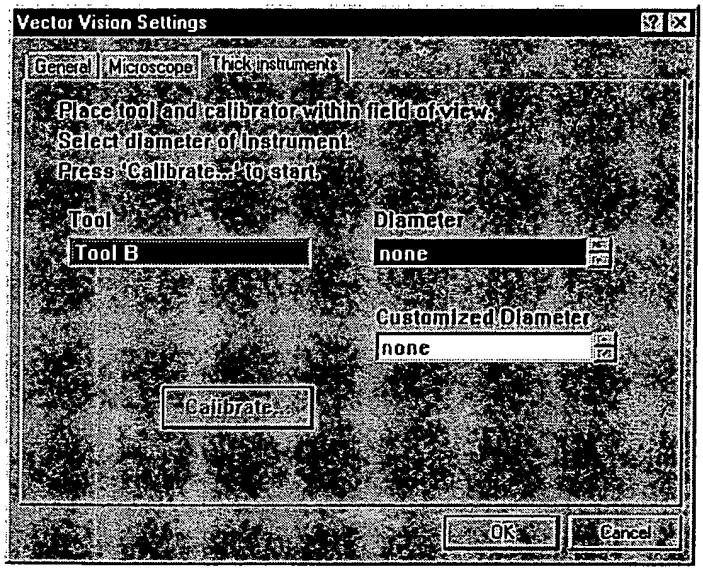


Figure 46: Tab box for calibrating thick instruments

Tool This field shows the actual tool name in the field of view and updates automatically. No user interaction possible.

Available Tools: Tool A, Tool B, Tool C and Tool D.

Diameter This field contains all available diameters (calibration holes). The user can select a diameter by clicking on the up/down arrows of this list box.

Available diameters: 2mm, 3mm, 3.2mm, 4mm, 4.5mm, 5mm, 5.5mm, 6mm, 6.7mm, 7mm, 7.5mm, 8mm, 8.5mm, 9mm, 10mm and 'custom' and 'none'.

Customized Diameter If an instrument has to be calibrated in the custom calibration hole, clicking on the up/down arrows can specify the real diameter of the instrument here.

Available custom diameters: 1mm up to 30mm in 1mm steps.

Calibrate... If enabled, this button starts the calibration procedure. The user must ensure that the instrument is inserted in the correct calibration hole corresponding to the specified diameter. The system has no possibility to verify the correct position of the Instrument in the TDC.

If calibration was started, the status field shows the following message:

Trying to calibrate Tool B with a diameter of 7mm.

For successful calibration the instrument and the TDC must not move relative to each other for at least 5 seconds.

If the system was not able to calibrate the instrument within 30 seconds the calibration is aborted and the message 'Calibration of thick instrument aborted. will appear in the bottom line

After successful calibration the following message in the bottom bar pops up.

Tool B has been calibrated with a diameter of 7.00 mm.

OK/Cancel Closes the VectorVision Settings Tab Box and returns to VectorVision treatment. The previous calibration of any instrument is not discarded, even if **CANCEL** was pressed.

Priority of tracking

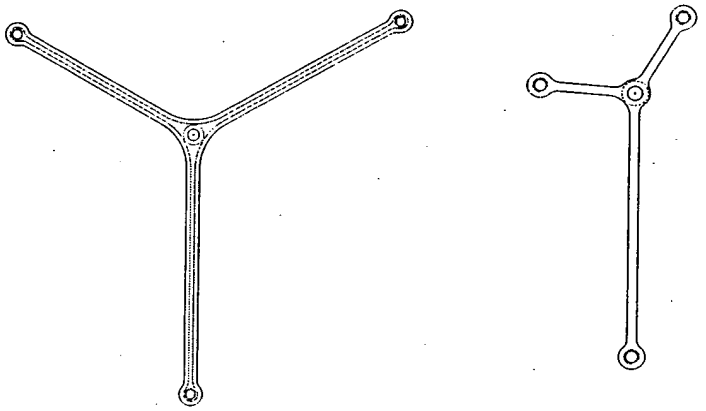
When using multiple tools simultaneously, the question comes up, which of the tools has current priority for navigation. This question is easily answered.

The marker arrays provided by BrainLAB are named from letter A to D, where array A has the highest priority and array E the lowest of all arrays corresponding to their size. The pointer tool has even a lower priority than array D. This means, that the tool, respectively the array, with the higher priority will perform all navigation features in all displays. A microscope linked to VectorVision always has the highest priority, even higher than array A.

Tip offset

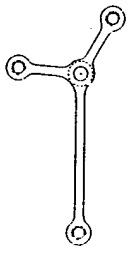
Please note, that any tip offset will affect all tools, but the tool calibration will still be performed correctly. We recommend always to use a marker array that is as big as possible for the tools to achieve the highest accuracy. It is also not very sensible to use the smallest array D with a long endoscope, for example. So keep in mind that the size of the marker array should be chosen so that the longest tool has the biggest array available.

Mounting direction Further, the marker arrays must be mounted longitudinally to the tool.

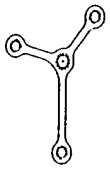


Star A

Star B



Star C



Star D

Figure 47: Reference Stars for Tool Adapters

STERILIZATION INFORMATION

CAUTION

Do not use cleaning solutions, solvents, or ultrasonic cleaners - except the cold soak specified above - to clean the parts of the VectorVision system.

CAUTION

The reflecting marker spheres of the VectorVision system may only be sterilized by gas or plasma! Any other technique, particularly heat, will destroy the markers. BrainLAB will not be liable to any damage of the markers due to improper sterilization.

WARNING

Contra-indicated for patients with Creutzfeld-Jakob Disease (CJD).

All parts of the VectorVision system are delivered non-sterile. Only the following components can and should be sterilized:

Part	Cleaning	Sterilization
Pointer tool Made from: PEEK (Polyetheretherketone) & stainless steel After removing the reflective marker spheres!	The pointer tool should be cleaned with soap and water and rinsed with distilled water to remove all traces of blood and dirt.	GAS, PLASMA OR NEUTRAL STEAM (< 130°C) STERILIZATION ONLY! NO ULTRASONIC CLEANERS!
Clamp (in four different sizes available) Made from: Aluminum, AlMgSi1, blue anodized e.g. for attaching the reference markers to the Mayfield adapter or for employing standard surgical tools for the use with VectorVision. After removing the reflective marker spheres!	With soap and water and rinsed with distilled water.	GAS, PLASMA OR NEUTRAL STEAM (< 130°C) STERILIZATION ONLY! NO ULTRASONIC CLEANERS!

Spinal Fixture Made from: Stainless Steel After removing the reflective marker spheres!	With soap and water and rinsed with distilled water.	GAS, PLASMA OR NEUTRAL STEAM (< 130°C) STERILIZATION ONLY! NO ULTRASONIC CLEANERS!
Reflecting marker spheres	Blood and dirt should be removed using a soft cloth moistened with a cold soak (Cytex™)	GAS OR PLASMA ONLY! NO ULTRASONIC CLEANERS! BrainLAB recommends the following procedure: Using Ethylenoxide in a concentration of 1 to 1,2 gram per liter at a temperature of 55° Celsius. After a sterilization time of 2 hours a "desorption- time" of 12 hours is recommended. Standard Plasmasterilization according the established standards using H_2O_2 is also possible.

Adhesive CT-Markers

Since these markers are used in the non sterile CT-environment, they don't have to be sterile. During surgery these patient markers are covered by a sterile draping. It is recommended they be cleaned with antiseptic soap and water between each patient use.

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